Conservation and Transformation of Energy

PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.2 Explain the factors that determine potential and kinetic energy and the transformation of one to the other.

Taxonomy Level: 2.7-B Understand Conceptual Knowledge

Key Concepts:
Potential energy
Gravitational potential energy
Kinetic energy

Previous/Future knowledge: In the 6th grade students explained how energy can be transformed from one form to another (including the two types of mechanical energy, potential and kinetic, as well as chemical and electrical energy) in accordance with the law of conservation of energy (6-5.2). In Physical Science the students will expand their concepts of kinetic and potential energy by explaining the transformations between the two and the factors involved.

It is essential for students to understand

- Transformations of potential and kinetic mechanical energy.
  - Mechanical energy is energy due to the position of an object or the movement of an object.
  - Mechanical energy can be potential or kinetic or the sum of the two.
- That *potential energy* is energy that is stored because of the arrangement of the system. Factors that affect gravitational potential energy are height and weight (mass times acceleration due to gravity, or $F_w=mg$).
  - Gravitational potential energy is greater when the height of an object is greater.
  - Gravitational potential energy is greater when the weight of the object is greater.
  - Gravitational potential energy of an object at some height is equal to the work required to lift the object to that height. Work is equal to force times distance (PS-6.3, 4); W = Fd.
- That *kinetic energy* is energy of motion. Factors that affect kinetic energy are mass and speed.
  - Kinetic energy is greater when the speed of an object is greater.
  - Kinetic energy is greater when the mass of a moving object is greater.
- Transformations can occur between gravitational potential energy and kinetic energy.
  Examples might include:
  Example 1
  - Lifting an object and dropping it
    - An object is on the ground. It has zero potential energy with respect to the ground.
    - It is lifted to some height. It now has potential energy equal to the work it took to lift it to that height. Its potential energy depends on its weight and height above the ground.
    - When the object is dropped, it is attracted by gravity and begins to speed up. Some of the energy turns to kinetic.
    - On the way down some of the energy is kinetic and some is potential, but the total remains the same.
    - Just before the object hits the ground most of the energy has turned to kinetic. It loses its potential energy because its height has gone to zero.
    - When the object hits the ground some of the energy turns to sound and some turns to heat because it speeds up molecules when it hits the ground.

Example 2

- A swinging pendulum
  - When a mass on a pendulum swings, it has mechanical energy. At the top of the swing all of its mechanical energy is potential energy that depends on its height and weight of the pendulum mass.
  - The kinetic energy is greatest at the bottom of the swing because the speed of the mass is greatest. Potential energy is zero at the bottom of the swing because the height of the mass is zero.
  - Between the top of the swing and the bottom of the swing the mass has both potential and kinetic energy because it has both height and movement (velocity).
  - Eventually the pendulum will stop. It stops because of friction.
  - The friction transforms the energy that was originally mechanical energy in the swinging pendulum into heat.

It is not essential for students to

- Calculate potential or kinetic energy using the GPE or $E_P = mgh$ or GKE or $E_k = \frac{1}{2} mv^2$, but reference to these formulas may help with instruction.

Assessment Guidelines:

The objective of this indicator is to *explain* factors that determine kinetic and potential energy and the transformation from one to another, therefore, the primary focus of assessment should be to construct a cause and effect model of how changes in height affect potential energy and changes in velocity affect kinetic energy and how these types of energy can transform one to the other. Assessments should require that students understand the relationships of height and weight on potential energy and speed and mass to changes in kinetic energy.

In addition to *explain*, assessments may require that students

- *Compare* kinetic and gravitational potential energy;
- *Infer* effects of changes in height and speed with gravitational potential energy and kinetic energy;
- *Exemplify* kinetic and gravitational potential energy and transformations between them;
- *Summarize* major points about kinetic and gravitational potential energy and transformations between them;
- *Classify* kinetic and gravitational potential energy.